this theory is very clean. If one assumes that an isolated black hole is surrounded by nothing, technically termed asymptotic flatness, all possible solutions, found by Roy Kerr[7], are characterized by only two parameters, the mass and angular momentum. Distortions by the pull from surrounding matter, such as an accretion disk, are, however, much more difficult to analyse. A first application of twisted light could be a test of whether Kerr's solutions provide the correct OAM spectrum. Or one could use alternative gravitational theories — such as those with additional scalar or vector fields, or candidates for quantum gravity — which would lead to modifications of the solutions and thereby different OAM spectra.

As an astrophysical tool, the twisting of light can be used to measure the mass-normalized angular momentum $a = J/Mc$ of a black hole by means independent of standard ones. In combinations with other observations such as the motion of nearby objects, the often considerable uncertainty in mass estimates could be reduced.

One might even begin to speculate about more exotic applications. The most interesting region of a black hole accessible to outside observers is the horizon, where spacetime is so severely distorted that the black hole's selfish gravity even keeps light to itself. Accretion disks cannot reach the horizon because stable orbits of small masses around the black hole have radii larger than the horizon size. Matter that comes closer quickly falls in without much time to shine. Accretion disks therefore cannot easily be used to explore the region very close to the horizon, but the horizon produces its own photons: Hawking radiation. The intensity for astrophysical black holes is extremely weak, too weak for Hawking photons to be seen among the noise of background radiation. But OAM might provide a clear, distinguishing signature that could one day lead to the observation of Hawking radiation. New calculations of the quantum processes that generate Hawking radiation are required, but before one can address that, the twisting of light already opens the way to exciting new possibilities in black-hole physics. ❐

Martin Bojowald is at Pennsylvania State University, 104 Davey Laboratory, University Park, Pennsylvania 16802-6300, USA.
e-mail: bojowald@gravity.psu.edu

References

1. Chwolson, O. *Astron. Nachr.* **221,** 329 (1924).
2. Einstein, A. *Science* **84,** 506–507 (1936).
3. Shapiro, I. I. *Phys. Rev. Lett.* **13,** 789–791 (1964).
4. LIGO and Virgo Collaborations. *Nature* **460,** 990–994 (2009).
5. Demorest, P. B., Pennucci, T., Ransom, S. M., Roberts, M. S. E. & Hessels, J. W. T. *Nature* **467,** 1081–1083 (2010).
6. Tamburini, F., Thidé, B., Molina-Terriza, G. & Anzolin, G. *Nature Phys.* **7,** 195–197 (2011).
7. Kerr, R. P. *Phys. Rev. Lett.* **11,** 237–238 (1963).
8. Molina-Terriza, G., Torres, J. P. & Torner, L. *Nature Phys.* **3,** 305–310 (2007).

Published online: 13 February

HENRY'S MOTOR

It doesn't work

"I have lately succeeded in producing motion in a little machine by a power, which, I believe, has never before been applied in mechanics — by magnetic attraction and repulsion. Not much importance, however, is attached to the invention, since the article, in its present state, can only be considered a philosophical toy; although, in the progress of discovery and invention, it is not impossible that the same principle, or some modification of it on a more extended scale, may hereafter be applied to some useful purpose."

With these modest words Joseph Henry began his description of one of the first electromagnetic machines. It was 1831, and the American scientist must soon have realized the wider potential of his invention. Over the years he kept improving the design of his 'little machines'. And although reciprocating motors were never to become a commercial success — motors producing continuous rotary motion turning out to be the way to go — the device gained its place in history as the forerunner of modern d.c. electric motors. Of the early Henry motors, only one surviving specimen (pictured) is known and has been on display since at least 1884, mostly at Princeton University. But, as Michael Littman and Lucas Stern have now found, that motor cannot operate (*Am. J. Phys.* **79,** 172–181; 2011).

M. G. LITTMAN

The device described in Henry's 1831 paper consists of a straight electromagnet with an iron core; pairs of whiskers extend beyond either side of the core, making connections alternately with two electrochemical cells, thus reversing the polarity of the electromagnet as the armature moves. Two vertical permanent magnets positioned beneath the ends of the electromagnet alternately attract and repel the beam, causing the armature to rock back and forth. Henry reported a frequency of 75 oscillations per minutes, "kept up for more than an hour".

The surviving motor at Princeton is of a slightly different design, in that the two vertical magnets are replaced by one long bar magnet (shown dismounted, in front of the motor). Exactly how this motor works is not obvious: Littman and Stern argue that it doesn't work at all.

In forensic detail, they have inspected and tested the Princeton motor — a configuration never actually described by Henry — and have found that there is something wrong with it. The strongest hint at the problem is that the surface of the wooden structures holding the bar magnet are rounded, suggesting that these supports are designed to cradle curved magnets. Indeed, Henry had described a design with C-shaped magnets, and Littman and Stern succeeded in locating an electromagnet (also pictured) of the correct size and shape in the Princeton collection. It seems that the motor has no design flaw *per se* — it has just been fitted, for more than a century, with the wrong part.

ANDREAS TRABESINGER